

1. (Currently Amended) An electronically commutated motor comprising:

a stator, a rotor, and a program-controlled

microprocessor, serving to control commutation of the motor;

an apparatus for ascertaining a time variable (t_H) corresponding to a rotation-speed-dependent time interval required by the rotor to rotate through a predefined angular distance, and being substantially inversely proportional to the rotation speed of the rotor;

an apparatus which triggers a rotor-position-dependent interrupt routine at predefined rotor positions;

an apparatus for calculating a first time interval (t_{TI}) dependent on that time variable (t_H);

an apparatus for triggering a motor control interrupt routine at an instant offset (t_{TI}) from a predefined rotor position, that offset corresponding to the first time interval (t_{TI}) dependent on the ascertained time variable (t_H);

wherein the motor control interrupt routine contains program steps for effecting a commutation of the motor.

2. (Previously Presented) The motor according to claim 1, wherein the motor control interrupt routine comprises program steps which prevent a commutation from being effected if the first time interval dependent on the sensed time variable is greater than a time span presently required by the rotor to travel through said predefined angular distance.

3. (Previously Presented) The motor according to claim 2, further comprising:

an apparatus which triggers a rotor position-dependent interrupt routine at predefined rotor positions.

4. (Previously Presented) The motor according to claim 3, wherein:

a timer, controllable by the rotor position-dependent interrupt routines, is provided, in order to sense the time variable that is substantially inversely proportional to the rotation speed of the rotor.

5. (Previously Presented) The motor according to claim 4, wherein:

the timer is also configured to trigger a motor control interrupt routine.

6. (Previously Presented) The motor according to claim 5, wherein:

the timer is loadable, during a rotor position-dependent interrupt, with a first predefined count value which corresponds to the time offset dependent on the ascertained time variable;

and which brings about a motor control interrupt after counting that first predefined count value.

7. (Previously Presented) The motor according to claim 3, wherein:

a rotor-position-dependent interrupt has a higher priority than a motor control interrupt.

8. (Previously Presented) The motor according to claim 4, wherein:

the timer, which in operation presents a timer value, is loadable, during a motor control interrupt, with a predefined count value;

and, subsequent to that loading operation, a count is performed until the next rotor position-dependent interrupt, so as to ascertain, by taking the difference between the predefined count value and the timer value upon reaching the next rotor position-dependent interrupt, a time offset between these interrupt operations.

9. (Previously Presented) The motor according to claim 8, further comprising:

an autoreload register for loading the predefined count value, which register stores the first predefined count value and feeds it to the timer during the motor control interrupt as the predefined count value.

10-29 (Cancelled).

30. (Previously Presented) A method of commutating an electronically commutated motor comprising a stator, a rotor and a program-controlled microprocessor serving to control commutation of said motor, comprising the steps of:

- a) ascertaining a rotation-speed-dependent value for a time variable (t_H) corresponding to a time interval required by the rotor to rotate through a predefined angular distance, and being substantially inversely proportional to the rotation speed of the rotor;
- b) from that time variable (t_H), calculating, according to a predefined calculation rule, a numerical value (t_{TI});
- c) measuring, beginning at a predefined first rotor position, a first time interval corresponding to that calculated numerical value;
- d) determining when said first time interval has elapsed, and thereafter triggering a commutation (TN);
- e) subsequent to the end of said first time interval, measuring a second time interval (t_1) until said rotor reaches a predefined second rotor position;
- f) adding the first and second time intervals to obtain, from their sum, a new rotation-speed-dependent value for the time variable (t_H) that is substantially inversely proportional to the rotation speed of the motor.

31. (Previously Presented) The method of claim 30, further comprising the step of:

correcting said sum by at least one correction factor.

32. (Previously Presented) The method according to claim 30, wherein:

said predefined calculation rule comprises

subtracting a predefined time from said time variable that is substantially inversely proportional to the rotation speed of the rotor.

33. (Previously Presented) The method according to claim 30, further comprising:

determining whether the first time interval corresponding to the calculated numerical value is greater than a time offset between the predefined first rotor position and the predefined second rotor position, and, if so, directly sensing the time offset between those two rotor positions and using the time offset as said time variable that is substantially inversely proportional to the rotation speed of the motor.

34. (Previously Presented) The method according to claim 30, further comprising:

comparing said time variable that is substantially inversely proportional to the rotation speed of the motor to a predefined value corresponding to a minimum rotation speed;

storing a logical value, corresponding to a result of said comparison result; and

if that logical value has a predefined value, suppressing the triggering of a commutation that would otherwise be accomplished after the first time has elapsed.

35. (Previously Presented) The method according to claim 30, further comprising:

detecting when a predefined rotor position is reached, and

executing a rotor position-dependent interrupt with an interrupt routine at the beginning of which a timer, providing time measurement, is stopped, and its instantaneous value is stored in a variable.

36. (Previously Presented) The method according to claim 35, further comprising:

in the rotor-position-dependent interrupt routine, stopping the timer providing time measurement, then loading the timer with a numerical value previously calculated in accordance with the predefined calculation rule, and thereafter restarting the timer.

37. (Previously Presented) The method according to claim 36, further comprising:

using the time span, between the stopping of the timer providing time measurement and the restarting thereof, as a correction factor during said step of ascertaining the time variable that is substantially inversely proportional to the rotation speed of the motor.

38. (Previously Presented) The method according to claim 30, further comprising the steps of:

ascertaining said rotation-speed-dependent value for said time variable which corresponds to a time interval required by the rotor to travel through a predefined angular distance from a first angular rotor position, and being substantially inversely proportional to the rotation speed of the rotor;

using said ascertained time variable in calculating said first time interval corresponding to the calculated numerical value, which is measured from a predefined first rotor position; and

measuring said first time interval, corresponding to said calculated numerical value, beginning at said first angular rotor position that is reached again after one rotor revolution.

39. (Previously Presented) The method according to claim 30, further comprising:

determining whether sufficient processor time is available for executing a predetermined non-time critical process step and, if so, executing a subroutine which performs said predetermined non-time-critical process step.

40. (Previously Presented) The method according to claim 39, further comprising:

calculating said rotation-speed-dependent value for said time variable that is substantially inversely proportional to the rotation speed of the motor, and calculating the numerical value on which measurement of the first time interval is based, as part of said subroutine executed when processor time is available.

41. (Previously Presented) The method according to claim 30, further comprising:

loading, from a nonvolatile memory associated with the motor, at least one parameter, necessary for calculations, into a random-access memory of the microprocessor.

42. (Previously Presented) The method according to claim 41, further comprising:

modifying, via a bus connection, at least one value stored in said nonvolatile memory.

43. (Previously Presented) An electronically commutated motor comprising:

a stator,

a rotor,

a microprocessor adapted for executing a program which controls commutation of the motor,

means for starting a timer with a predefined start value dependent on a time variable that is substantially inversely proportional to the rotation speed of the motor at at least one predefined rotational position of said rotor;

means, responsive to said timer, for triggering an interrupt in said program of said microprocessor after elapse of a time interval having a duration dependent on the start value; and

means for commutating said motor during said interrupt.

44. (Previously Presented) The motor according to claim 43, further comprising:

means for deriving the start value of the timer as a function of a rotation-speed-dependent time interval which the rotor has required, in a time period preceding that commutation, to rotate through a predefined rotation angle.

45. (Previously Presented) The motor according to claim 44, wherein said means for deriving further comprises:

means for subtracting a predefined time from the rotation-speed-dependent time interval as part of a calculation of the start value.

46. (Previously Presented) A method of determining a rotation speed-dependent variable in an electronically commutated motor which includes

- a stator,
- a permanent-magnet rotor,
- a galvanomagnetic sensor controlled by that rotor,

a microprocessor, a control program associated with that microprocessor, and a timer, comprising the steps of:

- a) converting an output signal of the galvanomagnetic sensor into a substantially square-wave signal;
- b) sensing, in the microprocessor, predefined signal changes of the square-wave signal and converting each signal change into a respective rotor-position-dependent interrupt;
- c) at a rotor-position-dependent interrupt, recording a first counter status of the timer;
- d) at a rotor position-dependent interrupt subsequent thereto, recording a second counter status of the timer;
- e) calculating a difference between the two counter statuses and deriving, from said difference, a value which corresponds to time required by the rotor to travel through a predefined rotation angle; and using said value as the rotation-speed-dependent variable.

47. (Previously Presented) An electronically commutated motor (M) comprising:

- a stator and a rotor,
- a program-controlled microprocessor, adapted for controlling the commutation of the motor; and
- a rotor position sensor whose output signal is applied, for purposes of analysis by the microprocessor, to an interrupt-capable input of that microprocessor, said for processing therein;

said microprocessor furnishing, at at least one output of the microprocessor, a control signal, for commutation of the motor, that is shifted, with respect to the signal of the rotor position sensor, by a shift time, the duration of the shift time being a function of the rotation speed of said motor.

48. (Previously Presented) The electronically commutated motor according to claim 47, wherein the microcontroller comprises at least one interrupt-capable timer with which the at least one output of the microprocessor, serving to deliver the control signal, is influenced.

49. (Previously Presented) The electronically commutated motor according to claim 48, wherein:

the timer is, in a specific state, automatically reloaded with a value and restarted.

50. (Previously Presented) The electronically commutated motor according to claim 48, wherein:

the microprocessor triggers an interrupt at each change in the signal of the rotor position sensor; and wherein:

the timer and the interrupts are used to measure a value dependent on rotor speed.

51. (Previously Presented) The electronically commutated motor according to claim 49, wherein:

the microprocessor triggers an interrupt at each change in the signal of the rotor position sensor; and wherein:

the timer and the interrupts are used to measure a value dependent on rotor speed.

REQUEST FOR RECONSIDERATION

Applicants acknowledge the Final Rejection of 1 JUN. 2005 and request reconsideration of the claims, as amended. The feature of claim 3 has been incorporated into main claim 1. Contrary to the contention at the top of page 5 of the Final Rejection, GEE does not provide an *enabling disclosure* (in his column 2) of the recited "apparatus which triggers a rotor-position-dependent interrupt routine at predefined rotor positions" together with the other elements recited in main claim 1. Columns 1-2 are merely the introduction to the GEE specification. Columns 4-9 provide the detailed description, and the Office has not pointed to any portion thereof which provide such an enabling disclosure. A reference which makes a suggestion, but **does not provide an enabling disclosure**, will not support an anticipation rejection. See CHISUM ON PATENTS, §3.04[1][b][iii], note 19, and Federal Circuit decisions cited therein, such as Rockwell International Corp. v. United States, 47 USPQ2d 1027,1031 (Fed. Cir. 1998).

Main apparatus claim 1 and main method claim 30 recite "a time variable (t_H) ... required by the rotor to rotate through a predefined angular distance." This time variable is short (has a small value) when the rotor turns quickly and is long (has a large value) when the rotor turns slowly. The variable is therefore a measure or "metric" for the rotation speed of the rotor.

The claims further recite calculating, from this time variable, a first time interval (t_{TI}) which is dependent upon the magnitude of the time variable (t_H).

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Subsequently, at a point in time which is offset relative to a predetermined rotor position by a time span corresponding to the first time interval (t_{TI}), a motor-control interrupt routine is triggered.

The routine contains program steps which carry out a "commutation" of the motor, i.e. switching current flow from one stator winding to another stator winding.

One thereby achieves the result that, as a function of the rotation speed, and fully automatically, the commutation timing is adjusted in such a way that the motor operates optimally.

This is shown by comparing FIG. 22 and FIG. 23. In FIG. 22, the present invention is not used, and therefore the motor current (i_M) has an undesirable form. As a result, the motor has poor power output and makes loud noises.

FIG. 23, by contrast, shows the result of using the present invention. The motor current (i_M) has a desirable shape. The power of the motor is significantly raised (without any extra "hardware" costs) and the motor runs quietly.

This also means that, given the same physical motor structure, by using the computer control of the present invention, the motor can achieve a higher RPM (FIG. 23) than it could by operating without the present invention (FIG. 22). The efficiency of the motor is significantly improved by the present invention. The entire series of steps is set forth in the program. The motor already has a microcontroller for purposes of commutation, so no additional hardware cost is required, just the one-time cost for correct programming!

ART REJECTION--SECTION 102

GEE (USP 4,743,815), cited as allegedly anticipating claims 1 and 30 and their dependent claims, uses a different and more complicated motor control scheme. GEE column 2, lines 21-31, contrary to the Office's contention on page 4 of the Final Rejection, does not teach how to use a rotation-speed-dependent parameter as taught by Applicants. Rather, GEE detects the zero-passage of the induced

voltage ("back-EMF"), and this zero-passage triggers an interrupt at position ZR. See col. 4, lines 64-68.

GEE discloses triggering the interrupt in either of two ways: either according to the "Sensorless principle" using detectors 21 of FIG. 3 and the monoflop of FIG. 4, or according to Hall sensors H1, H2, H3 of FIG. 6, and the associated circuit shown in FIG. 6.

Further, on the basis of this interrupt, GEE performs a commutation in the angular region from ZR to NG (FIG. 2) as described at col. 4, lines 18-22, and this happens, as described at col. 7, line 66, through col. 8, line 8, in dependence upon a target value THC which is set using a potentiometer; see col. 8, lines 4-5. This is shown in GEE's FIG. 7A flowchart, on the right side, captioned "CLOSED LOOP."

According to FIG. 7A, the rotation speed is detected, and this is used to increase the voltage parameter V_{LIMIT} as the RPM increases. However, according to GEE, the RPM is used only in the complicated computation described in his column 8, in contrast to the present invention. Rather, in GEE, the motor current timing is specified by the angle THETA. This happens at the same place during the rotation of the rotor, namely at the zero-passage ZR of the trapezoidal induced voltage VZN, as shown in FIG. 2.

It should now be apparent that GEE fails to suggest or make obvious the subject-matter recited in independent claims 1 & 30, much less their respective dependent claims 2-29 and 31-42. Claims 43-45 contain a similar recitation "time variable that is substantially inversely proportional to the rotation speed of the motor." Independent claim 46 recites a "rotation speed dependent variable."

Independent claim 30, in contrast to apparatus claim 1, is directed to a method, as shown in FIG. 7, i.e. starting from the predetermined rotor position HN, the calculated time interval T_B (alternatively called t_{TI}) is measured, and, upon the expiration of this calculated time interval, commutation happens at $TN+1$. Thereafter, the measurement continues at $TN+1$ and an interval t_1 is measured. this is added to time t_B , and one thus obtains the duration of signals t_{HN+1} and of the signal HALL of FIG. 7A. This manner of measuring has the advantage that one can measure both time intervals by means of a single timer. It is apparent that GEE also fails to provide suggestions or teaching in this direction. The same goes for independent claims 43 and 46.

REFERENCES "OF INTEREST"

Applicants comment on the references cited in § 45.

Müller/Papst (USP 4,531,059) is directed to a signal generator for the motor of a hard disk (HD).

In a hard disk, one needs a signal whenever the rotor passes a predetermined rotational position. This signal then controls the read and write processes. Without such an exact signal, the hard disk controller would not know exactly, in which rotational position the rotor finds itself. According to the Müller reference, such signals 16, 17 (FIG. 4) are generated very simply and without great cost.

For this purpose, one employs a magnetization shown in FIG. 3, i.e. the pole boundary 31 is shifted somewhat in the rotation direction 15, and the pole boundary 32 is shifted somewhat opposite to the rotation direction; see col. 3, lines 46-52.

Further, one also employs, in addition to the motor windings 3, a special auxiliary winding 6, which is constructed as a so-called "full-pitch" winding (col. 3, lines 37-63) and obtains at this

auxiliary winding the two needle pulses 16, 17 which are shown in FIG. 4.

As shown in FIGS. 5-8, the pulses 16, 17 are transformed in an integrator 23, 24 into a voltage u_2 , and the voltage u_2 is transformed in comparator 27 into a square wave voltage u_3 (FIG. 7). The voltage u_3 can be used to control data transmission onto the hard disk.

The Müller disclosure fails to suggest the present invention because the phase position of the voltage u_3 cannot be varied, and furthermore for controlling the current in stator winding 3, a special control track 14 of the rotor magnet is provided, into which the variations 31, 32 of the pole boundaries don't extend; see col. 3, lines 52-57. This control track serves to achieve a symmetrical commutation using a HALL integrated circuit; see col. 4, lines 43-48. A temporal shifting of the commutation, depending upon the RPM, is not possible here.

Alternatively, as described at col. 5, lines 56-66, a so-called "commutation with integrated voltage" would be possible. According to that, the induced voltage in the stator winding 3 could be applied to a microprocessor, which in turn would control the commutation. However, here also, it would not be possible to vary the instant the commutation happens, dependent upon the RPM.

JESKE/PAPST (USP 5,831,359) is directed to improving the Hall signal which is generated by Hall generator 14. This Hall sensor is shifted oppositely to the rotation direction 72 and this makes it hard to obtain a good Hall signal, since the Hall sensor lies beneath the claw 30.

For this reason, claw 30 is formed with a recess 76, and this recess causes the Hall signal to be better. FIG. 17 shows the Hall signal u_H without this recess, and FIG. 18 shows the Hall signal $u'H$

with the recess, and one can readily see the difference. This is also described at col. 5, lines 37-41.

JESKE also fails to suggest the present invention, since the phase position of voltage $u'H$ shown in FIG. 18 is not dependent upon the RPM of the motor.

The Examiner's attention is respectfully directed to specification pages 26ff. According to page 26, last paragraph, for motor control, it is important, what is the relative priority of a rotor-position-dependent Hall interrupt and a timer interrupt, in case these interrupts happen simultaneously. Referring to FIG. 6B, the theoretical timer-interrupt of FIG. 6B would be, under fast-acceleration conditions, to the right of Hall-interrupt HN+1. Conversely, the time interrupt in FIG. 7B is to the left of Hall interrupt HN+1, representing "early ignition" at high rotation speeds. Between the conditions of FIG. 6B and that of FIG. 7B, the timer interrupt can migrate from the sector to the right of the Hall interrupt into the sector to the left of the Hall interrupt. This presents the possibility that the Hall interrupt and the timer interrupt could occur more or less simultaneously, so it is necessary to specify which interrupt the microprocessor should execute first.

FIG. 5, mentioned by the Examiner, shows only the case of "early ignition" according to FIG. 7B (see specification page 9, second par.) and FIG. 5 thus does not illustrate a situation of simultaneous interrupts.

Claim 38 recites a "first angular rotor position that is reached again after one rotor revolution" since the timing is not predetermined but it dynamically calculated, during operation, by the control circuit.

With respect to claim 46, it should be noted that the GEE reference does not use a rotor position sensor, but instead relies upon sensing "BACK-EMF" (see col. 1, line 8). Claim 46 calls for a rotor position sensor, so GEE clearly does not teach in the direction of this claimed structure. The same is true of claim 47 and claims dependent thereon.

CLAIM REJECTION-SECTION 102

GEE & THORN/EMERSON ELECTRIC (USP 4,743,815) discloses a three-phase motor with a control scheme based upon the Zero-Crossing points (ZR) of the induced voltage (see col. 4, line 15). The DC power supply voltage (col. 4, line 28) increases with increasing rotation speed. The motor uses phase-chopping control, i.e. the turn-on instant is after the associated zero crossing point (see col. 8, line 12). Thus, the GEE motor belongs in the "late ignition" genre, not the "ignition advance" genre of the present invention. Upon each zero passage of the induced voltage, an interrupt is generated by the monoflop 37 of FIG. 4 (see col. 6, lines 28-29) or alternatively, by gate G15 of FIG. 6.

FIG. 2 shows the induced voltages ("back-EMFs") VAN, VBN and VCN in phases A, B, and C, with reference to neutral point N.

The bottom trace in FIG. 2 shows the zero passages ZR and the points NG where the induced voltage reaches its negative maximum. The commutation happens in this sector between ZR and NG, as described at col. 4, lines 18-33. The "ignition angle" measured after ZR, is designated THETA (see col. 7, lines 66ff). For it, a potentiometer is used to set a "commanded phase angle" THC (col. 8, lines 1-8). This angle determines the power of the motor.

At startup, no induced voltage is present, so the motor operates under "open loop" control. This is shown in FIGS. 7A and 7B, on the left side of each. Beginning at a specified RPM, the flag BSYNCC is set to 1 (FIG. 7C, bottom), and thereafter the motor operates under "closed loop" control, as a function of the induced voltage or back-EMF.

The description in GEE is, to a great degree, unclear and non-enabling. The command or target value for the phase chopping angle THETA is designated THC and set manually using a potentiometer, not shown (col. 8, lines 4-5 and 27-28). The comparison of THC and THETA is shown in FIG. 7A.

It is unclear, how the motor can start at all. The routine of FIG. 7A is executed 120 times per second (col. 7, lines 50-56). If the motor is still, one naturally cannot detect a zero passage, so it is unclear how a start is possible. Perhaps turning by hand?

From the foregoing, it should be apparent that about all the GEE disclosure has in common with the present invention is the use of interrupts in an electronic commutation-control circuit of a DC motor; GEE fails to teach or suggest the other features of claims 1-9, 30-38, and 43-51, as amended. The section 102 rejection must therefore be reconsidered and withdrawn.

CLAIM REJECTION-SECTION 103

Dependent claims 39-42 were rejected as unpatentable over GEE, combined with "Official Notice" that those in the computer control arts know when to execute non-critical process steps. Dependent claims 39-42 incorporate by reference the six method steps recited in independent claim 30. Contrary to the recitations on page 6 of the Final Rejection, GEE col. 7, lines 36-63, do not disclose ascertaining first and second time intervals as recited in steps c) and e) and GEE does teach how to use about rotation-speed-dependent variables which are **inversely** proportional to rotation speed. At most, GEE mentions frequency FRQ (col. 7, line 59) which is **directly** proportional to rotation speed and a "time per step" TS (col. 8, line 44). Therefore, GEE does not provide **the predicate** to dependent claims 39-42, much less suggest the **additional** features recited in claims 39-42.

With respect to claim 39, the Office has not pointed to any mention in GEE of "non-time-critical process steps," much less to a teaching of **when** to execute such steps.

Claim 40 further specifies calculation of a "rotation-speed-dependent value" which is not mentioned in GEE col. 7, lines 36-63.

Claim 41 recites loading a startup value from a non-volatile memory, of which no mention in GEE has been cited.

Claim 42 recites modifying the contents of the non-volatile memory of claim 41, via a bus connection. No bus connection and no content-modification step in GEE have been cited.

The Office is requested to reconsider the section 103 rejection, in the light of the amendments made, and in the light of the Ex parte Scott & Lin decision of the Board of Appeals concerning "Official Notice" taken in S.N. 09/392,276, now USP 6,727,578, issued 27 APR. 2004. In that case, the Board found that the Examiner's "Official Notice" rejection was based on impermissible hindsight reasoning.